B-8 Research on the Interaction between the Cloud Systems and Dynamical Processes Related to the Climate Change (FY 1990~1992)

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The state of generation and distribution of cloud systems over the earth has large influence on the global climate system through radiative feedback effects and also through the latent heat release accompanying the phase change of water. This study aims to clarify the dynamical and the thermodynamical processes associated with the organization of the cloud systems and to contribute to make an adequate model for simulating the clouds' role in climate system properly.

1. The Structure of Super Cloud Clusters Observed in 1-20 June 1986. (Data analysis)

Dynamical structures associated with very distinguished 3000 km scale organization of convective cloud systems in the equatorial region, super cloud clusters, were studied. The GMS IR fundamental histogram data and the Global Objective Analysis Data prepared by JMA were utilized for the analysis. The analysis period is 1~20 June 1986 during which four super cloud clusters successively propagated eastward over the equatorial western Pacific Ocean.

Main results are as follows. (1) The organized cumulus convective activities of the super cloud clusters observed in this period were associated with two kinds of dynamical modes. One was the eastward propagating Kelvin wave-type mode on the equator and the other was the westward propagating vortex-type mode at several degrees north of the equator. (2) The horizontal structure of the equatorial eastward propagating mode (Fig. 1) showed the distinguished amplitude between 10°N and 10°S with the dominance of the zonal wind component. The longitudinal scale of this mode was 6000~8000km and the propagation speed was 10°~12°/day. The phase relation between the wind and the height anomaly (not shown here) can be called a Kelvin wave-type mode. Energetically, direct interaction between the eastward mode and the convection was not observed, while the energy flux input to this mode from the southern hemisphere was indicated in the upper troposphere. (3) The structure of the westward mode associated with the westward traveling cloud clusters corresponded to the "easterly waves" (Fig. 2). The "easterly waves" was amplified to the west of the lower convergence of the eastward mode while the amplitude was decreased to the east. This mode was maintained with the energy conversion from the cumulus-producing available potential to the kinetic energy.

2. The Numerical Study on the Characteristics of the Cumulus Parameterization Schemes.

In order to compare the characteristics of the two different cumulus parameterization schemes, GCM experiments with simplified lower boundary conditions were carried out. The numerical results were analysed in regard to the difference in systematic behaviorof the cumulus convective activities and also in their connection with the dynamical disturbances. Compared parameterization schemes are Kuo (1974)'s scheme (hereafter referred to as KUO) and Manabe et al.(1965)'s scheme (as MAA).

For the time-mean features, the KUO experiment exhibited two precipitaion bands straddling the equator, while the MAA experiment showed relatively flat precipitaion distribution over the equatorial zone. This is probably due to the difference in evaporation effectiveness over the equator between two schemes.

Figure 3 shows the longitude-time sectional diagram of the precipitation over the equator with (a)KUO and (b)MAA. The eastward propagating wavenumber one feature is common in two experiments. However, smaller, order of 1000 km, scale precipitation patterns are very different. The cause of this difference was found in the connection between the convective activities and the dynamical disturbances. In the KUO case, the 1000 km-scale precipitation systems were associated with wave disturbances maintaining the wave-CISK (energy feedback system between the convection and the wave) structure, while in the MAA case, no such systematic association was found.

Further experiments with detailed analyses are required in order to compare the cumulus parameterization schemes under consideration of the real phenomena.

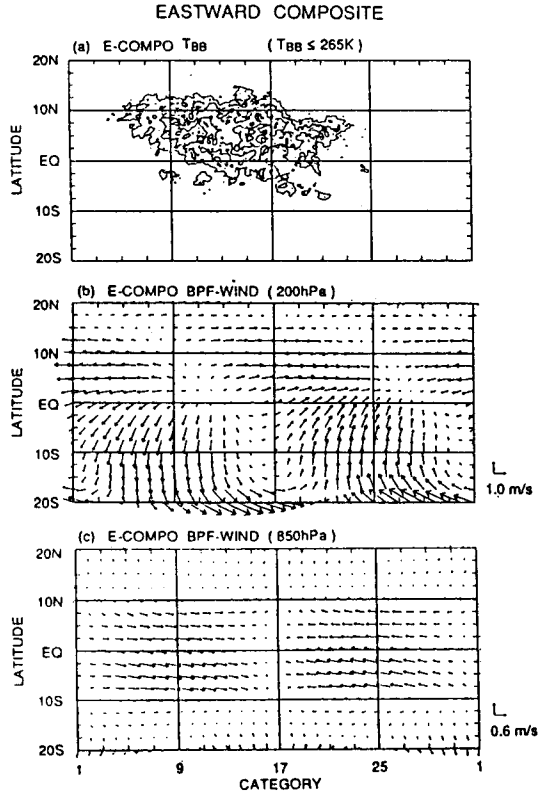

Fig.1 The composite structure of the eastward mode. Abscissa is the category which corresponds to the relative longitude from the disturbance center (about 6000~8000 km from left to right). (a) TBB ≤ 265K, (b) 200 mb horizontal wind and (c) 850 mb horizontal wind. (TBB stands for the equivalent blackbody temperature)

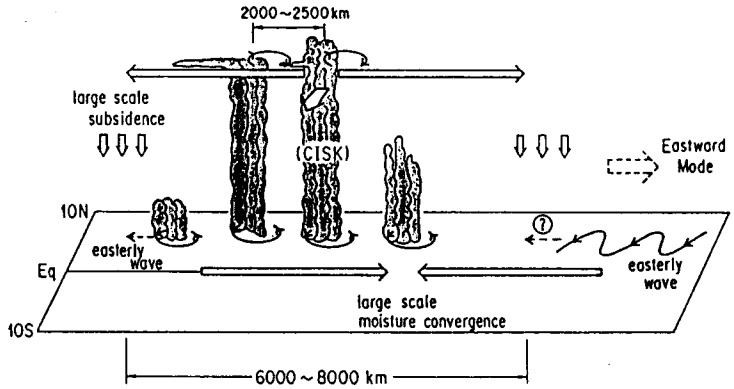

Fig.2 Schematic picture of the systems associated with a super cloud cluster.

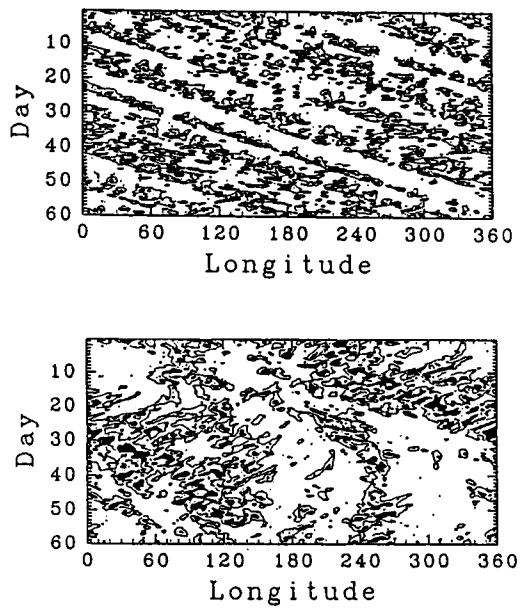

Fig.3 Longitude-time diagram of the precipitation over the equator obtained in (a) KUO experiments and (b) MAA experiments.